NASA SBIR Super Subtopic
“Balloon Telescope Assembly”

H. Philip Stahl, Ph.D.

Sub-Topic Manager

New Concept

Super Sub-Topic has higher limits:

Phase 1	up to $200K
Phase 2	up to $1.5M

To accomplish tasks too big for standard sub-topics.

For each Super Subtopic, we expect to fund:

Phase 1	2 to 3
Phase 2	1 to 2

Funded projects will be assigned a NASA Science PI.

Motivation

Astro2010 Decadal Report recommended increased use of sub-orbital balloon-borne observatories.

Two specific needs include:

Far-IR telescope systems for CMB studies

Optical/NIR telescope systems for Dark Matter and/or Exoplanet studies

Balloon Telescope Assembly

Build one or more telescope assemblies for a potential balloon mission:

- Grazing Incidence X-Ray Telescope
- Ultra-Stable 1-meter Class UVOIR Telescope
- Low-Cost CMB Telescopes
- Low-Cost Far-Infrared Telescopes
- Cryogenic Far-Infrared Telescope
- 5 to 10 meter Segmented Far-IR Telescope
- Heliophysics UVOIR Telescope

Phase 1 deliverable is reviewed design ready for manufacture.

Phase 2 deliverable is a fully integrated and tested telescope assembly, ready to be incorporated into a potential balloon mission payload.

Successful Proposals Shall

Provide credible plan to deliver telescope ready to be integrated into a balloon mission. Past experience will be given appropriate weight.

Demonstrate understanding of how engineering specifications meets science requirements and balloon operational envelop:

- Thermal Environment from 330K to 150K
- 10G shock
- Constrained Mass Budgets

Phase 1 delivery plan includes optical, mechanical (static and dynamic), thermal designs and performance analysis.

Phase 2 delivery shall be a completely assembled and tested telescope assembly ready to be integrated into a potential balloon mission. Testing shall confirm compliance of the telescope assembly with its requirements.

X-Ray Telescope

A complete grazing incidence x-ray telescope is desired with:

- effective collecting area of ~3 cm^2 for 0.1-4 nm wavelengths,
- 4 meter effective focal length,
- 0.8 degree angle of incidence, and
- surface roughness of 0.2 nm rms.

Ultra-Stable 1-meter Class UVOIR Telescope

Potential Exoplanet balloon studies require a telescope with:

- Collecting aperutre of 1 meter or larger collecting aperture
- diffraction limited at 500 nm
- Spectral range from 300 to 1100 nm (ideally 1600 nm)
- Field of view > 10 arc-seconds
- Field of regard from 20 to 70 degrees elevation angle
- Dynamic wavefront stability < 0.3 nm rms per 100 seconds
- Real centimeter scale image
- Total mass ~ 300 kg.

Telescope can achieve the stability requirement via either passive design or an actively controlled mirror (i.e. secondary mirror, fine steering mirror, deformable mirror, etc.)

Un-obscured off-axis system is preferred, but on-axis systems with simple secondary support spiders are allowed.

Low-Cost CMB Telescopes

Potential balloon measurements of CMB linear polarization require complete off-axis telescope systems with the following optical, mechanical and operational requirements.

Optical requirements:

- 3 meter to 4 meter diameter primary mirror
- Diffraction-limited performance at 500 micron wavelength at 250 K
- Wavefront stability of 15 micrometers rms per K
- F/1 to F/1.5 primary mirror
- 70 arc-minute field of view at 500 micron wavelength
- Strehl ratio > 0.95 at edge of field of view

Mechanical and operational requirements

- Telescope to operate at ambient temperature 250 K (200 to 300K range)
- Telescope and mount to survive 10G shock (vertical)
- Telescope and mount to survive 5G shock (tilted 45 deg)
- Mass of telescope to be 200 kg or less
- Recurring production cost < $200 K per telescope

Low-Cost Far-Infrared Telescopes

Potential balloon Far-IR missions require complete off-axis telescope systems with the following optical, mechanical and operational requirements.

Optical requirements:

- 2.5 meter to 4 meter diameter primary mirror
- Diffraction-limited performance at 100 micron wavelength at 250 K
- Wavefront stability of 2.5 micrometers rms per K
- F/1 to F/1.5 primary mirror
- 15 arc-minute field of view at 100 micron wavelength
- Strehl ratio > 0.95 at edge of field of view

Mechanical and operational requirements

- Telescope to operate at ambient temperature 250 K (200 to 300K range)
- Telescope and mount to survive 10G shock (vertical)
- Telescope and mount to survive 5G shock (tilted 45 deg)
- Mass of telescope to be 200 kg or less
- Recurring production cost < $200 K per telescope

Cryogenic Far-Infrared Telescope

Potential Far-Infrared balloon missions achieve significant improvements in sensitivity using cryogenic optics. Anticipated missions require a complete telescope system with 3 meter on-axis collecting aperture maintained at temperatures below 20 K. Low mass and long cryogenic hold time are particularly important.

Optical requirements:

- Diffraction-limited performance at 300 micron wavelength at 20 K
- F/1 to F/1.5 primary mirror
- Field of view 20 arc-minutes minimum, 40 arc-min desired
- Strehl ratio > 0.95 at edge of field of view

Cryogenic requirements

- Maintain entire telescope at 20 K or colder
- Hold time 48 hours or longer, with goal of 21 days

Mechanical requirements

- Telescope and cryostat to survive 10G shock (vertical)
- Telescope and cryostat to survive 5G shock (tilted 45 deg)
- Mass of telescope + cryostat to be < 1000 kg (goal 500 kg)

5 to 10 meter Segmented Far-IR Telescope

Potential Far-IR balloon studies required a complete optical telescope system with a 5 to 10 meter segmented aperture; 250 to 500 micrometer diffraction limited performance; wavefront stability of less than 10 micrometers rms; and a total mass of 400 (5m) to 800 kg (10m).

Heliophysics UVOIR Telescope

Potential Heliophysics studied require a complete optical telescope and/or camera system with: 1 to 2 meter collecting aperture, 20 degree field of view, 0.001 degree angular resolution and UV to Visible (120 to 700 nm) spectral range.

Any Questions?